DISTRIBUTION AND DEVELOPMENT OF ROOT MATS IN THE SOUTH CAROLINA PIEDMONT [1]

Rebecca E.B. Ball, Thomas A. Waldrop, and Steven M. Jones [2]

Abstract. Fire prescriptions developed for the fell-and-burn technique in the Southern Appalachian Mountains can result in excessive erosion when used in the Piedmont. The difference has been attributed to thin root mats (F and H forest floor layers) which are entirely consumed by high-intensity site preparation burns. This study examined litter layer (L layer) and root mat thickness across three successional stages and three types of sites to identify where root mats may be thick enough to allow burning. Preliminary indications are that root mat thickness is more closely related to site type than successional stage. A lack of information is indicated on the relationship of moisture to decomposition, root growth, root survival, and litter deposition.

Introduction

Establishment of pine-hardwood mixtures by the fell-and-burn technique (Abercrombie and Sims 1987) has proven successful in the Southern Appalachian Mountains. The procedure provides a low-cost alternative to expensive site preparation necessary to convert hardwoods to pine monoculture (Phillips and Abercrombie 1987). The technique involves spring felling of residual trees after a commercial clearcut, summer site preparation burning, and planting pine at wide spacings to allow hardwood regrowth. The burn reduces growth of the competitive hardwood sprouts allowing pine seedlings to become established (Waldrop and others 1989).

The high-intensity burning used in this technique has not been shown to cause significant erosion in the Southern Appalachians. Van Lear and Danielovich (1988) found that soil movement on a mountain site was not significantly increased because 22% of the root mat (F and H layers) remained intact and mineral soil was exposed on only 15% of the site. However, in a comparative study in the Piedmont, Van Lear and Kapeluck (1989) showed soil loss of 207 tons/acre/year when burning was conducted under a similar prescription and with similar aboveground fuels. The difference in erosion rates was attributed to differences in thickness of the forest floor. Mountain sites tended to have root mats that were from 3 to 5 inches thick before burning. Root mats of Piedmont sites were generally less than 1 inch thick and little was left after burning. McCracken and others (1989) reported a root mat that was 0.8 inch thick in a virgin Piedmont forest.

Successful application of the fell-and-burn technique in the Piedmont will likely be limited to only those sites where the root mat is thick enough that it is not entirely consumed by burning. Root mats protect the soil from erosion by absorbing kinetic energy of rainfall and by acting as a sponge to allow water to seep into the soil gradually (Wilde 1971). They also hold moisture on the site by acting as a mulch (Waldrop and others 1989).

Little is known about the factors that affect root mat development or how to identify sites in the Piedmont where it is likely thick enough to allow site preparation burning (Waldrop and others, 1989). Factors such as aspect, slope position, soil physical properties, time since disturbance, degree of disturbance, and vegetation cover may be important factors in the development of this necessary resource. This information would assist forest managers to identify sites that are likely to have root mats of sufficient depth to protect the soil from erosion and thin areas with high potential for erosion.

This study examines the variability of forest floor characteristics across the Midlands Plateau Region of the Piedmont Province in South Carolina. The specific objectives were to determine the relationship of root mat thickness to site types and to time since disturbance, or seral stage.

Methods

A model of ecosystem units for the Piedmont Province of South Carolina (Jones 1989) using the Landscape Ecosystem Classification (LEC) concept was used as a tool to define site types. This model

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[1] Paper presented at the Seventh Biennial Southern Silvicultural Research Conference, Mobile, AL, November 17-19, 1992.

[2] Graduate Research Assistant, Clemson University, Clemson, SC; Research Forester, SE Forest Experiment Station, Clemson, SC; and Assistant Professor, Clemson University, Clemson, SC.

describes site units across a moisture gradient by: 1) landscape position (slope position and aspect), 2) soil information (depth to clay and percent clay in the inhibiting layer), and 3) presence of indicator plant species. The model includes five site units that range from the xeric site unit found on upland slopes with shallow soils to the mesic site unit found on lower, protected slopes with deep soils.

For this study, a subset of stands was sampled from those of the original study (Jones 1988). Sampled stands included those of the xeric, sub-xeric, and intermediate site units (mesic and submesic were excluded) which were in one of three successional stages: early successional pine, mid-successional oaks, or old-growth mixed hardwoods. Three stands were sampled from each site unit-successional stage combination. All stands were in the Midlands Plateau Region of the Piedmont Province in South Carolina. The early and mid-successional stands were around 50 years old and the old-growth hardwoods were around 150 years old. Old-growth stands were chosen that were clearly within a specific landscape unit as interpreted by Jones (1988) from DECORANA ordination (Hill 1979). Early and mid-successional stands were chosen by comparing individual stand data to ensure the plot met the soil, landform, and vegetation requirements for a specific unit.

Sampling occurred within the same 33 x 131 ft (10 x 40 m) plot that was established for the LEC study. Starting at a random point within each plot, and using a 5-by-4 grid, twenty sub-plots were sampled at 13 ft (4 m) intervals. Each sub-plot was located at least 3.3 ft (1 m) from trees over 4.5 in (11.4 cm) dbh to eliminate large woody roots from the study. This factor occasionally resulted in a non-random starting point.

At each sub-plot, the thicknesses of the litter layer (L layer) and root mat (F and H layers) were measured at twenty systematic points using a 5 by 4 grid sampling frame (Ball 1992). Means of litter and root mat thickness for each stand were tested for significant differences across a spatial-temporal interaction gradient through General Linear Models Procedure (GLMP) and Duncan's Multiple Range test. The study used a 3 by 3 factorial arrangement (3 site units by 3 successional stages) of a completely random design. Differences were considered significant at the 0.05 level.

Results

There was little variation in litter layer thickness across site units and successional stages, ranging from 0.7 in. on sub-xeric site units to 1.1 in. in early-successional stands on xeric site units (Fig. 1). On xeric and intermediate site units, there was a general trend for the litter layer to become thinner in the later successional stages. However, there were no significant differences between successional stages for all site units combined or within the sub-xeric and intermediate site units. On xeric site units, the litter layer was significantly thicker in early successional stands (1.1 in.) than in mid-successional (0.9 in.) or old-growth stands (0.8 in.).

When successional stages were combined, litter thickness was significantly greater on xeric (0.9 in.) and intermediate (0.9 in.) site units than on sub-xeric units (0.7 in.). Even though this pattern was most pronounced in early-successional stands, it was significant only in mid-successional oak stands. There, litter thickness was 0.7 in. on sub-xeric site units and 0.9 in. on xeric and intermediate site units.

Root mats were much thinner in this study than previously measured on mountain sites. On these Piedmont sites, root mats ranged from 0.6 in. thick in mid-successional stands on intermediate site units to 1.2 in. thick in early successional stands on xeric site units (Fig. 2). There was no clear pattern of root mat development across the successional gradient. On xeric and intermediate site units, root mats tended to be thicker in early-successional pine stands than in either type of hardwood stand while the opposite pattern was observed on sub-xeric site units. However, none of these differences was significant.

With successional stages combined, there were no significant differences in root mat thickness between site units. However, there was a strong pattern within the two types of hardwood stands (mid-successional oaks and old-growth mixed hardwoods). In these stands, the root mat was significantly thinner on intermediate site units than on xeric and sub-xeric site units. The thickest root mat occurred on sub-xeric sites. This pattern agrees with McCollum (1992) who found above- and below-ground root development to be greater on sub-xeric than on xeric and intermediate site units.

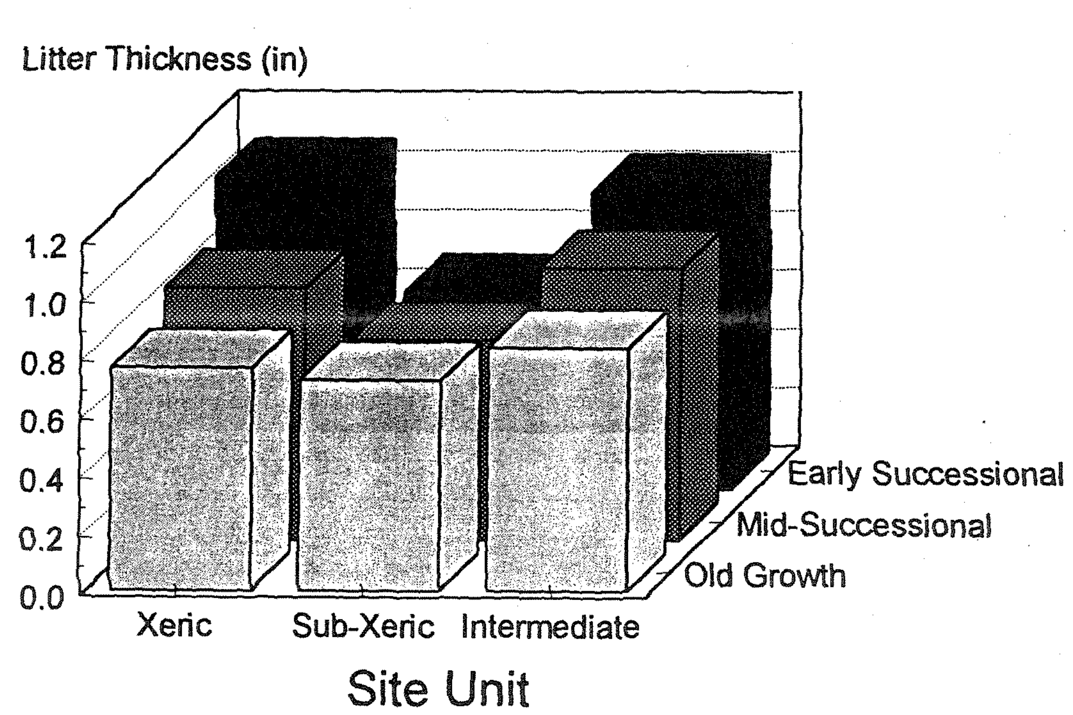

Figure 1. *Litter layer thickness by site units and successional stages across the South Carolina Piedmont.*

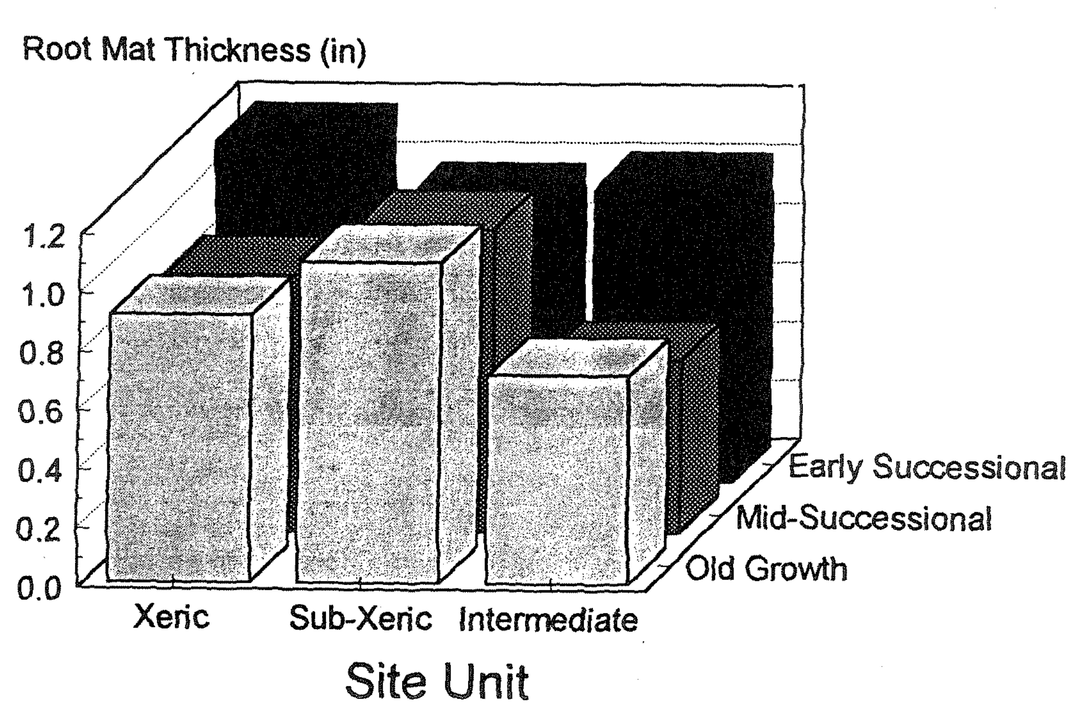

Figure 2. *Root mat thickness by site units and successional stages across the South Carolina Piedmont.*

Discussion

An early assumption in designing this study was that the amount of time since a major disturbance would have an impact on the development of the forest floor, particularly on the thickness of the root mat layer. However, the successional gradient chosen for this study failed to show a clear pattern. The litter layer tended to become thinner over time on two of three site units (Fig. 1), which may be due to the increased hardwood composition and the associated increase in decomposition rates. However, this pattern did not hold for root mats, which tended to be thicker in early-successional pine stands but showed no difference between the mid-successional oaks and the old-growth mixed hardwoods.

Arp and Krause (1984) found that forest floor characteristics such as oven-dried mass per unit area, depth, moisture content and several chemical attributes varied widely over a stand. They recommended that 10% of a site be sampled to obtain 95% confidence. This study covered only about 1% of each stand, which may have masked differences between successional stages.

A somewhat more meaningful pattern of forest floor development occurred across site units, particularly if the two hardwood successional stages are considered separately from the early-successional pine. The dry, xeric site units and the moist, intermediate site units typically had thick litter layers and thin root mat layers. Sub-xeric site units, which are more moist than xeric and drier than intermediate site units, were characterized by thin litter layers and thick root mat layers.

These patterns may be due to a combination of site quality and decomposition rates. Litter layers may be thicker on intermediate site units because more litter is produced on the higher-quality sites. Although xeric site units likely have less litter production, limited moisture would reduce the abundance of decomposing fungi and micro-arthropods. Sub-xeric site units likely have lower litter deposition than intermediate site units and greater decomposition than xeric site units.

McCollum (1992) suggested that root development, and thus root mat thickness, was related to the moisture gradient across site units. On xeric site units, root growth and survival is likely low due to limited moisture availability. Root growth is low on intermediate site units because of higher moisture availability. On sub-xeric site units, moisture availability may be low enough to demand increased root development but high enough to allow root survival.

Conclusions

Regardless of the time since disturbance, site unit, or species composition (pine vs. hardwood), the root mat of South Carolina Piedmont forests was much thinner than in the mountain areas where the fell-and-burn technique has been successful. This pattern suggests that the prescriptions used for site preparation burning used in the Southern Appalachians should be altered to adapt to the thin conditions of the Piedmont. Future studies should examine the root component of root mats to determine if they have sufficient soil holding capacities to prevent erosion after a fire. Also, research is needed to develo guidelines for fire prescriptions for each site unit.

Due to the inherent variability of soil patterns of forest floor development observed in th study produced few differences that were statistical significant. Therefore, definitive guidelines f identifying stands with root mats thick enough protect from burning cannot be stated. However, si units appeared to more important than succession stages. Stands on sub-xeric site units had thicker ro mats than those on xeric and intermediate site unit Explanations for this pattern are mostly speculati but they indicate the need for a better understandi of forest floor development processes between si units. Future studies should focus on the relationsh of moisture to the balance of root growth, ro survival, decomposition, and litter production on ea site unit.

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